International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 05, May-2019

A Review - Design and Analysis of Leaf Spring using Composite Material

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Abstract—Suspension system of the vehicle is a major part where weight reduction is possible so by replacing a conventional leaf spring with composite leaf will help in the weight reduction of vehicle because suspension system of vehicle is consisting around 30-40 % of vehicle body weight. In this paper main aim is to focus on this kind work in which the weight reduction of vehicle was achieved by replacing conventional leaf spring with composite leaf spring.

Keywords— Composite Leaf spring, CREO, ANSYS, Pro-E, Glass Fiber, Epoxy

I. INTRODUCTION

There are different types of materials for metallic springs depending on the application. The materials used for such springs are principally, SAE-1080, 1095, 9250-60.

It is well known that springs, in general, are designed to absorb and store energy and then release it. Hence, the strain energy of material becomes a major factor in designing the springs.

Specific strain energy of the leaf spring: $U=\frac{\sigma^2}{\rho E}$

Where, σ = Strength, ρ = Density, E = Young's modulus

It can be said that the material with lower modulus and density will give a greater specific strain energy capacity. Hence, composite material becomes a very strong candidate for such applications because of it high strength to weight ratio.

II. LITERATURE REVIEW

E. Janarthan,M. Venkatesan[1] carry out the experimental and computer aided analysis using FEA of the composite leaf spring. Three sample of the fiber glass reinforced plastic were prepared.
40% epoxy 60% E glass
60% epoxy 40% E glass
70% epoxy 30% E glass
UTM used for flexural test and hardness test conducted using Rockwell L- scale.

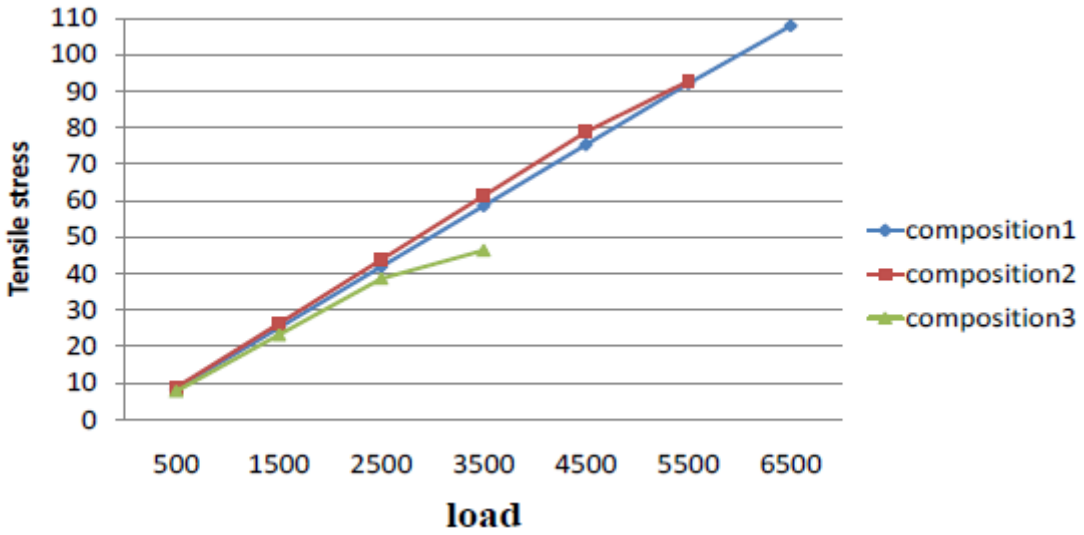

Figure 1: Graph of Tensile stress (Mpa) vs load(N)

It shows that composition 2 with 60 % epoxy and 40% E-glass gives the better result compare to other two compositions.

Y. N. V. Santhosh Kumar & M. Vimal[2] deals with the replacement of conventional steel leaf spring with a Mono Composite leaf spring using E-Glass/Epoxy. The leaf spring was modelled in Pro/E and the analysis was done using ANSYS software.
The three cross-sections of leaf spring for easiness are considered.
Constant thickness, constant width design
Constant thickness, varying width design
Varying width, varying width design.
It was observed that the composite leaf spring weighed only 39.4% of the steel leaf spring for the analysed stresses.

E. Mahdi, O.M.S. Alkoles, A.M.S. Hamouda, B.B. Sahari, R. Yonus, G. Goudah[3] work on the influence of ellipticity ratio on performance of woven roving wrapped composite elliptical springs has been investigated both experimentally and numerically. The ellipticity ratio significantly influenced the spring rate and failure loads. Results are shown in a graph.

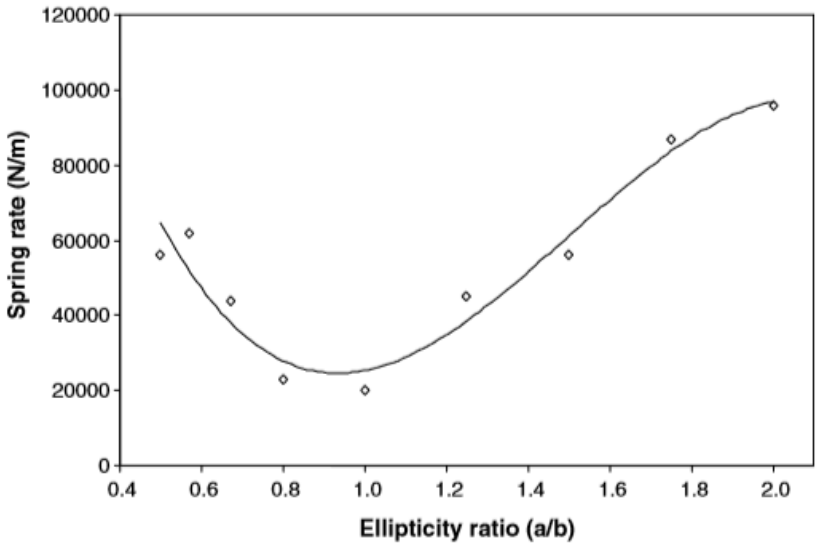

Figure 2: Graph of Spring rate vs Ellipticity ratio (a/b)

H.A. Al-Qureshi[4] presents a general study on the analysis design and fabrication of composite springs. A jeep was selected as a prototype. A single leaf spring with GFRP (glass fiber reinforced plastic) was designed, fabricated and tested. The testing was performed experimentally in the laboratory and was followed by the road test. These test are limited to ride quality and sound observation on different road conditions and they observed that GFRP spring were more flexible and less noisy compare to steel leaf spring.

Pradipkumar Kakadiya, Darshan Kapadia[5] aim to reduce the overall weight of suspension system and improve load carrying capacity of the leaf spring by using the composite material.Materials used for comparison are conventional material like steel and CFRP. The solid modeling of leaf spring is done in CATIA V5 R21 and analysed using HYPERWORK 14.0. Before optimization the weight of steel suspension system and CFRP suspension system is 26 kg and 5.332 kg respectively and after optimization weight of steel suspension system and CFRP suspension system is 18.51 kg and 3.79 kg respectively. After optimization 28% weight reduction is possible to achieve.

Sorathiya mehul, dhaval b. Shah, Vipul[6] describes static analysis of steel leaf spring and laminated composite Multi leaf spring.
The composite material is used for analysis is carbon epoxy.
From this analysis they found that 79.617 % weight reduction in composite material has been achieved for same number of leaves.

Mahmood M. Shokrieh , Davood Rezaei[7] work on a four-leaf steel spring used in the rear suspension system of light vehicles is analysed using ANSYS software with the aim to obtain a minimum weight spring that will not fail under same force conditions. ANSYS software is used for analytical analysis of a leaf spring. They found that the spring width decreases hyperbolically and the thickness increases linearly from the spring eyes towards the axle seat & weight reduction is possible up to 80%.

Thippesh L[8] work with a mono composite leaf Spring of unidirectional glass fiber reinforced plastic with similar mechanical and geometrical properties to the multi leaf steel spring, was fabricated and tested for static strength. The objective was to obtain a spring with minimum weight that is capable of carrying external forces without failure.

Compare to steel springs, the composite spring has stresses that are much lower, the natural frequency is higher and the spring weight is reduced considerably.

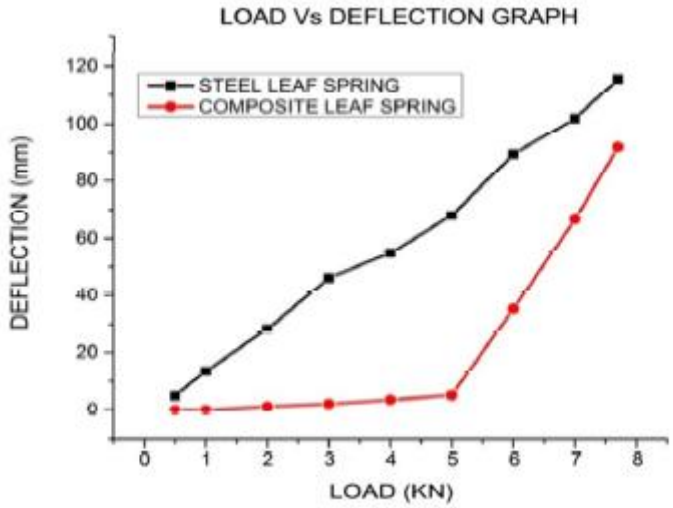

Figure 3: Load vs deflection graph

Three point bending test has been conducted on steel and hybrid mono composite leaf springs. The total weight of composite mono leaf spring is 5Kg and 5.2 Kg including the metal eye weight. The weight of a convectional steel spring assembly is around 26 Kg. So, around 80% of weight reduction is achieved. Thus the objective of reducing the spring mass is achieved to a larger extent.

Dasari Ashok Kumar and Abdul Kalam SD[9] carried out a research with the aim of replacement of the leaf spring with composite leaf spring made of E-Glass Epoxy. ANSYS software is used for analytical analysis. The results are compared with the theoretical values and found in permissible limit. The analysis is performed in three phases. They are by varying the load applied on the leaf springs, by varying the normal penalty stiffness (FKN) of contact pair, by varying the thickness of the composite leaf spring.In this it was found that the composite material leaf spring having a lesser stress of 52.65% than the steel leaf spring, and having higher stiffness of 49.943% than steel leaf spring. The conventional multi-leaf spring weights about 29.191 kg but whereas the E-Glass/Epoxy multi-leaf spring weighs only 8.654 kg thereby weight reduction of 69.48% has been achieved.

Pankaj Saini, Ashish Goel, Dushyant Kumar[10] work with the objective to compare the stresses and weight saving of composite leaf spring with that of steel leaf spring. The design constraint is stiffness. The Automobile Industry has great interest for replacement of steel leaf spring with that of composite leaf spring, since the composite materials has high strength to weight ratio, good corrosion resistance.The design parameters were selected and analysed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring. The leaf spring was modelled in Auto-CAD 2012 and the analysis was done using ANSYS 9.0 software.

R D V Prasad, R.Sai Srinu , P.Venkata[11] work on the development of analytical formulation for Composite leaf spring and comparing the obtained results with the Conventional Steel leaf spring with 4 leaves. Composite leaf spring in this project has been developed as a mono block construction with maximum thickness at the center which is preferably glass fiber reinforced polymer. The existing leaf spring dimensions are taken and solid model is made using CATIA V5 and then analysed using ANSYS software.

Vivek Rai , Gaurav Saxena [12] deals with the replacement of multileaf steel spring with mono composite leaf spring for the LCV. Suspension system in an automobile determines the riding comfort of passengers and the amount of damage to the vehicle. The main objective of this paper is to replace the multi-leaf steel spring by mono composite leaf spring for the same load carrying capacity and stiffness.

III. CONCLUSIONS

After review all papers we concluded that the remarkable weight reduction in possible in a vehicle suspension system by replacing conventional leaf spring with composite leaf spring. The weight reduction is depending on the material used for composite leaf spring. carbon fiber is given us a more weight reduction than glass fiber but cost will increase. So there is a still chance of improvement by better optimization of cost and material.

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